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Published in:
ASSETS '14 Proceedings of the 16th international ACM SIGACCESS conference on Computers & accessibility

DOI:
10.1145/2661334.2661371

Publication date:
2014

Buildings and Users with Visual Impairment: Uncovering Factors for Accessibility using BIT-Kit

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ABSTRACT

In this paper, we report on the experiences of visually impaired users in navigating buildings. We focus on an investigation of the way-finding experiences by 10 participants with varying levels of visual ability, as they undertook a way-finding task in an unfamiliar public building. Through applying the BIT-Kit framework in this preliminary user study, we were able to uncover 54 enabling and disabling interactions within the case study building. While this building adhered to building legislation, our findings identified a number of accessibility problems including, issues associated with using doors, hazards caused by building finishes, and difficulty in knowing what to do in the case of an emergency evacuation. This user study has demonstrated a disparity between design guidance and the accessibility needs of building users. It has uncovered evidence to enable architects to begin to design for the real needs of users who have a range of visual impairment. Furthermore, it has instigated discussion of how BIT-Kit's evidence could be incorporated into digital modeling tools currently used in architectural practice.

Categories and Subject Descriptors

J.5 [Arts and Humanities] Architecture; K.4.2 [**Computers and Society**] Social issues – *Assistive technologies for persons with disabilities.*

Keywords

Accessibility; architecture; buildings; visual impairment; way-finding; methods

1. INTRODUCTION

Architectural design is failing to meet the needs of many end users, particularly those who experience an impairment or disability. We are all aware, for example, of building requirements for wheelchair users and guidelines for Braille in buildings. In many cases, however, implementations of such designs fail to achieve the stated goal. From an architectural perspective, this is due to a lack of method in gathering evidence to understand the accessibility of buildings by the people who use them.

The built environment is the context for human activity. However, buildings that have failed to include the needs of users in the design process are often not fully accessible. The result is a building whereby the user experiences exclusion and disablement, and the client experiences costly, inconvenient accessibility interventions. A particular issue is the lack of design evidence in relation to what enables and disables people with visual impairment as they undertake the task of way-finding in buildings [2, 18].

The built environment is failing to support people who have a form of visual loss. Described as an *'assault course'*, the building *'poses the most serious threat to independence and full social integration'* [3]. Goldsmith [10] recognizes this as a form of '*Architectural Disablement'*.

Previous approaches in relation to understanding this problem area have focused developing models or theoretical structures of way-finding. However, the detail and real-world evidence of what enables and disables people with visual impairment is missing. Furthermore, methods to gather this evidence are lacking. Current guidance and legislation fail to provide designers with user-evidence that is transferable into accessible design practice [19]. Graphical representations (such as space syntax models), concentrate on modelling the spatial layout and environmental performance of places in relation to crowd flow, as opposed to individual's experience. Similarly, when adopting qualitative methods, the users 'voice' often becomes lost as the individual's perspective and tacit experience are diluted when converted into legislation, guidelines and access checklists. Popular strategies of utilising 'specialists' and simulating impairment are also frequently adopted, yet flawed in reliability [6].

The issues with accessibility in the built environment bear a striking resemblance to issues with technology accessibility. While numerous guidelines exist for accessible development (IBM), in many cases technologies that are fully compliant still fail to meet the needs of disabled users [21].

We describe BIT-Kit, a user-focused evidence-gathering tool, composed of semi-structured interview, observation of buildings in use, and user's interaction trace. This combination of methods is proposed to complement and strengthen the weaknesses of a single method approach. Our goal with this work is to consider the experiences of visually impaired users as they navigate buildings, determining if and when the built environment – built to meet building codes for accessibility – actually meets their needs.

In comparison to previous approaches, BIT-Kit allows built environment professionals to identify the location and reason behind enabling and disabling interactions within the building. Furthermore, to have impact in the accessibility of both new buildings and retrofit projects, there is potential for BIT-Kit's evidence to be embedded in the digital modeling tools (e.g. BIM, CAD and Sketch-up), currently used in architectural practice.

2. RELATED WORKS

We discuss the existing approaches to understand interactions by people with visual impairment as they undertake the task of way-finding within the built environment. Although this work parallels what architects consider when designing homes for people with dementia, [24], literature assessing the impact the built environment has on people with visual impairment is limited.

Previous works have identified that the built environment is failing to support people who have a form of visual loss [3] however they give no evidence based on the needs of building users with visual impairment. The task of way-finding within a public building is raised as a particular problem [2] because most designers give way-finding low priority, seeing it as a hindrance to good design or a problem to be solved with signage [5].

There is a lack of contemporary research within the profession to enable architects to mitigate problems and enhance solutions. Furthermore, research has tended to concentrate on cognitive mapping abilities of people with visual impairment [16] as opposed to capturing actual evidence of experience associated with using a building (e.g. accessibility issues experienced when trying to find the restroom or opening a fire-safety door).

Way-finding is the process of getting from A to B. It is user orientated and is the cognitive, behavioral and strategic task of planning movement [2]. It is a process composed of four sub-tasks: 1.Orientation, 2.Choosing and planning the route, 3. Keeping on the right track - Navigation, and finally 4. Discovering (and stopping at) the destination [7, 8]. It is knowing what direction and course of action is needed to reach a destination [2, 7, 11]. It is a form of goal-directed movement [2]. An un-successful way-finding task can leave a person 'lost' or disorientated in their surroundings [11].

It is a complex set of cognitive, behavioral and physical processes which are widely debated across disciplines. Familiarity of routes, building type, type of way-finding, information availability and its synthesis, individual's abilities and cognitive processes are all factors impacting on and influencing way-finding.

The psychologists' view that Cognitive Mapping is the process which enables way-finding by the 'product' of the cognitive map [7, 8] is put into practice by researchers such as Lynch [17] who has investigated ways that people structure their cognitive maps. However, this process of cognitive mapping is doubted by researchers, such as [2, 15], who argue that the skill to way-find is not acknowledged. Instead, Arthur and Passini [2] Information Processing Model puts the importance on the informative aspects of way-finding.

Whilst Lynch [17] claimed that *'Nothing is experienced by itself, but always in relation to its surroundings, the sequences of events leading up to it, the memory of past experiences.'* Brambring [13] and Harper and Green [12] fail to take this into account. Their models focus on an individual journey undertaken by a blind person however do not consider the impact these journeys have on the ability to learn or remember routes. They also fail to consider the complicated varying experiences and spectrum of visual loss.

There is a lack of a way-finding model, which incorporates all types of visual ability that is based on both experience and is in relation to a real-world setting [16]. Strategies of utilizing 'specialists' and simulating impairment are frequently adopted in architecture practice and education as a way to understand users needs [1, 22]. However, users need to be represented in accessibility research in order for inclusive design to have a positive impact on people's lives [23].

Quantitative algorithmic techniques such as work carried out by Space Syntax [14], has provided tools for architects to simulate the effects and impact of decisions on the relationships between people and the built environment. They are usually presented as digital representations of physical space in the format of site plans overlaid with matrixes' of flow patterns. These allow architects to quickly read and understand the simulations of user behavior in relation to the context of a specific setting. However, these algorithms are abstract and reductive representations of generic users. They fail to capture the diversity of the population and lack the detailed understanding of the individual and their needs. Overall, this is a recognized failing of the quantitative methods in general.

3. BIT-KIT: THE BACKGROUND

There are few evidence-based studies of way-finding in a building. Furthermore, there are no studies of real-life experiences of way-finding undertaken by real-life participants with a range of visual ability. This is a significant gap in architectural knowledge.

To address this gap, we applied both algorithmic techniques and qualitative interview-based analyses to understand how people with visual impairments use buildings. There was an absence of a single methodology that would fully meet the needs of this type of investigation. Therefore, a theoretical foundation was created from the established approaches of Grounded Theory [9] and Case Study [25], in addition to methods currently adopted in architecture (e.g. analysis of floor plans).

There was also lack of a single method that would let us gain insight into the accessibility challenges encountered by people in buildings. Limitations of previous work caused by, a lack of user experience [17], a use of method which either lacked qualities [14] or quantities [2], and a concentration on the extreme edges of impairment or disability (e.g. studies only involving legally people [12, 13]), were several of the factors that influenced the core elements of BIT-Kit.

3.1 BIT-KIT: The FRAMEWORK

We propose BIT-Kit, the Building Interactions Tool-kit [20], to facilitate the gathering of evidence of how buildings impact (both good and bad) on the accessibility of users. BIT-Kit comprises a mixed-method approach, incorporating semi-structured interview, observation of buildings in use and traces of users interactions.

This combination of methods provides detailed traces of user interactions, evidence and understanding of the disabling and enabling elements of a building.

3.1.1 Interviews

Interviews are used to gain qualitative insight into both past and present experiences of using and interacting with buildings. Beginning as unstructured interviews, to remain as open as possible, the interview becomes a planned approach that utilizes an initial framework of topics focused on the overall research question or hypothesis.

ID	*Age*	*Gender*	*Aid*	*Self-definition and Age of VI*	*Mobility Training*
P1 'Alfie'	55	Male	Symbol Cane *"I never leave the house without someone else with me"*	*"I am in total darkness all the time. I can see nothing." (50)*	No
P2 'Katie'	50	Female	Guide Dog *"We go everywhere together."*	*"Totally Blind. I have no useful sight at all when I am out and about." (21)*	Yes
P3 'James'	60	Male	Roller Cane	*"Registered Blind"(Since Birth)*	Yes
P4 'Evie'	65	Female	Sliding Cane	*"I have degenerative sight- loss, Peripheral vision only, sensitive to light and have double vision"(50)*	Yes
P5 'Lily'	30	Female	White Cane	Degenerative sight-loss. *"I can only see things that are really close to my face"* (13)	Yes
P6 'Adam'	20	Male	No Mobility Aid, wears prescription lenses	Degenerative sight-loss. *"no working iris, sensitive to light and registered partially sighted" (Since Birth)*	No
'Emma'	23	Female	Long Cane *"the occasional borrowed elbow of a friend"*	No vision in left eye and *'about 10-15% of vision in my right eye"(4)*	No
P8 'Jack'	21	Male	Corrective Lenses, Wheelchair and Mobility Assistant	*"I can only see straight ahead."* No peripheral vision. *(Since Birth)*	No
P9 'Grace'	40	Female	No Mobility Aid, Prescriptive Lenses	*"I am either short or long sighted – I can't remember" (Recently)*	No
P10 'Ben'	24	Male	No Aid	*"no visual loss"*	No

The framework of topics evolves through each interview to become a semi-structured interview. Data, recorded on a Dictaphone, is downloaded, transcribed and coded using qualitative analysis software (such as Atlas.ti). This approach enables rich narrative and insight to be gained in relation to users experiences of buildings.

3.1.2 Traces of Users' interactions
User's movements through a building, or interaction with a specific element of architecture are plotted on floor plans of the building. Patterns, individual behaviors and spatial information in context, can be understood through these traces. In addition these interaction traces can convey evidence back to built environment professionals.

3.1.3 Observations of buildings in use
Within BIT-Kit, participants undertake an observed task or interaction with a building to enable understanding of the building being used. By employing this method we can define the events that are actually happening and assess how the person is being impacted by the building (i.e. positive or negative experiences). It is also possible to identify how other situational variables, such as other people or temporary changes within the building impact on experience. Through the use of observations we are able to gather the contextual information in regards to what is happening.

4. USER STUDY
The objective of this user study was to apply the BIT-Kit approach to a real world scenario. We investigated the enabling and disabling experiences of 10 participants with varying levels of visual ability, as they undertook a way-finding task in an unfamiliar public building [18].

4.1 Participants
Ten participants (5 male and 5 female, ages 20 to 70), who had a range of visual impairment (in addition to other disabilities), were recruited to take part in the Way-finding Scenario, following ethical approval from the University of Dundee. Table 1 provides an overview to the participants. The group as a whole is representative of a range of visual impairment.

4.2 Equipment and Software
A Dictaphone was used to record the interviews and a Panasonic SDT-S7 Digital Camera was used to record a video of the participant's way-finding journeys.

Qualitative Data Analysis & Research Software, ATLAS.ti was used to analyze the interview data. Timeline-based video editing software, Adobe Premier Pro was used in observations of the way-finding journeys. Adobe Premier Pro and Computer Aided Design software, AutoCAD (Version 17.0) were used together in order to plot and analyze users interaction trace from the film footage.

4.3 Procedure
The Way-finding Scenario comprised three sequential phases. The user study was designed to evaluate both the pre-existing memories of way-finding in a building and the experience of a way-finding task within a public building.

4.3.1 Phase 1: A Chat-Way-finding in Buildings.
Purposeful conversation [4] was adopted as an unobtrusive way to initially gather narrative of general way-finding topics and experiences of participants' way-finding in buildings. The purposeful conversation was a planned approach, which utilized

an initial framework of topics that evolved throughout each way-finding scenario to become semi-structured interviews.

In remaining open, these interviews were focused to uncover insight into the participant demographic information and includes details of; their self-definition of their visual impairment, when their visual loss occurred, the types of way-finding aids they currently used and if they had ever undertaken orientation and mobility training.

Recorded by Dictaphone and later transcribed, all interviews went through a process of coding using the constant comparison technique of Grounded Theory [9]. The data open-coded to produce an initial code list, which through iteration was developed until the analysis reached theoretical saturation, with respect to the amount of data. Relationships were established between the categories identified in the open coding through axial coding. The data was selectively coded in terms of core and subcategories from the initial and axial list.

4.3.2 *Phase 2: The Way-finding Task.*

Immediately following Phase 1, participants took part in a way-finding task within the way-finding setting during the building's regular opening times. They were asked to find their way from a starting point (the boundary wall of the building) to a destination point (an office within the building) and were not provided with any directional guidance.

Each Participant was asked to undertake the task as they normally would when visiting an unfamiliar building (i.e. if they normally asked at the reception for directions then they should ask the receptionist in this building for directions). The way-finding task was not run on a timed basis. Participants carried a small digital video recorder that captured their *'way-finding encounters'*.

This quantitative data was transcribed onto floor plans of the building and became the participants *'Way-finding Trace'* (Figure 1) still images were also captured and aided in building understanding of what was actually happening at specific points in the building.

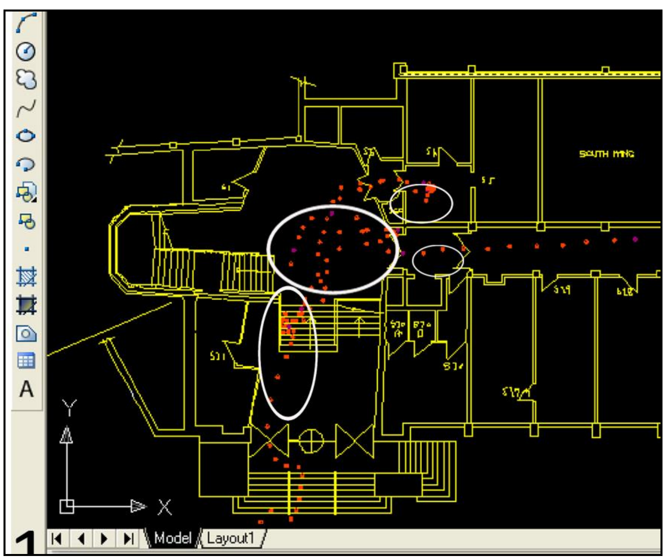

Figure 1 Way-finding Trace

4.3.2.1 *The Building*

The building selected for the way-finding scenario was a large, semi-public building that was fully compliant with building legislation. The selection of the building was based on a number of logistical factors (e.g. regular opening times), the complexity of the building and architectural elements available (e.g. stairs, number of floors) and the ability to gain access to the floor plans for data recording and analysis.

4.3.3 *Phase 3: Observations/ Reflection Interviews.*

Observations and Reflection Interviews in relation to Phase 2 were implemented immediately following the way-finding task. Purposeful conversation, which developed into a semi-structured interview, was utilised again to focus on participants' experiences of way-finding in a specific building. It was found that participants' memories of previous way-finding experiences were activated by events that happened during Phase 2 and they also talked about these. The researcher undertook observations of the way-finding task using the video camera footage. From this footage the entirety of each participant's way-finding journey could be understood in relation to the contextual, social and temporal elements of the building.

5. DATA ANALYSIS AND RESULTS

The BIT-Kit approach has uncovered 54 enabling and disabling experiences. Coined Hotspots, these are the encounters and interactions (positive and negative) that impacted on a person's experience of way-finding. In this paper we present several findings that provide insight into the types of insight extracted from employing this user-based approach.

5.1 Results

Using BIT-Kit within this case study has uncovered both qualitative and quantitative evidence of what enables and disables the task of way-finding by people with visual impairment. Through analysis of data it emerged that there were key events and occurrences, 'hotspots', which occurred within a way-finding journey and impacted on a way-finders experience of using the building. They were spatial conditions, social interactions, or temporal events. Hotspots were positive experiences such as using ground textures to find the front door of a building or being able to break a journey to find the toilets. Hotspots were also negative experiences such as not being able to understand or use way-finding signage or not being able to find and follow a route through a building because of a change of use or extension. The hotspots uncovered were the evidence to understand the impact the building had on the people using it.

Figure 1 illustrates data of a physical way-finding trace of a participant walking through and interacting with a building (each second in time is represented as a dot on the floor plan). The clusters of dots highlight a hotspot of movement – a key area of interest or critical significance – when all movement has slowed down or stopped altogether. This highlights to us that something has happened within this specific area of the building in response to either physical impediment or decision-based change in trajectory. Data collected from interviews, conversations and observations will illuminate whether hotspots are positive or negative and the underlying reason(s) for it occurring in the specific location of the building.

5.2 BIT-KIT, data analysis and 'Hotspots'

The challenge, when working with this data set, was the synthesis of different types of data (i.e. interview, floor plans, still images and film footage, illustrated in figure 2). Once this was achieved, there were different ways to identify hot spots. Each method used

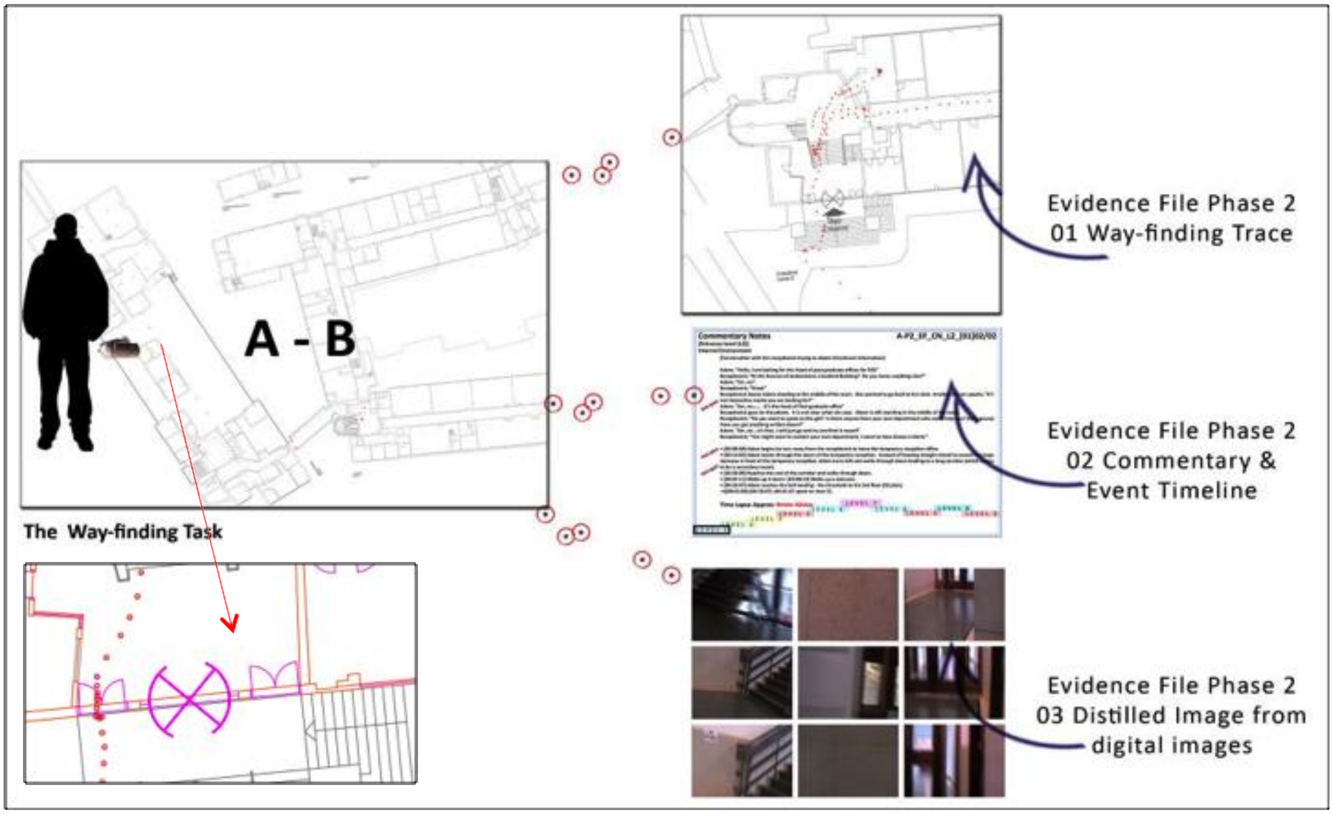

Figure 2: Quantifiable Trace Hotspots and Observations

within BIT-Kit has uncovered hot spots, both individually and through data fusion (across 2 or more Phases).

5.2.1 Memories of Hotspots

Memories of past way-finding experiences through a building, specifically talked about in Phase 1, were identified and extracted as quotes when the participants referred to way-finding being hindered or enhanced by an event in a building. This type of hot spot is exemplified by Katie's experience of a glass staircase (Figure 3), which was encountered in a different building from the case-study setting. She explained,

'He (her guide-dog) won't go up stairs if they are open in any way or if they are made of glass. He can't see where to put his feet, so he just refuses.'

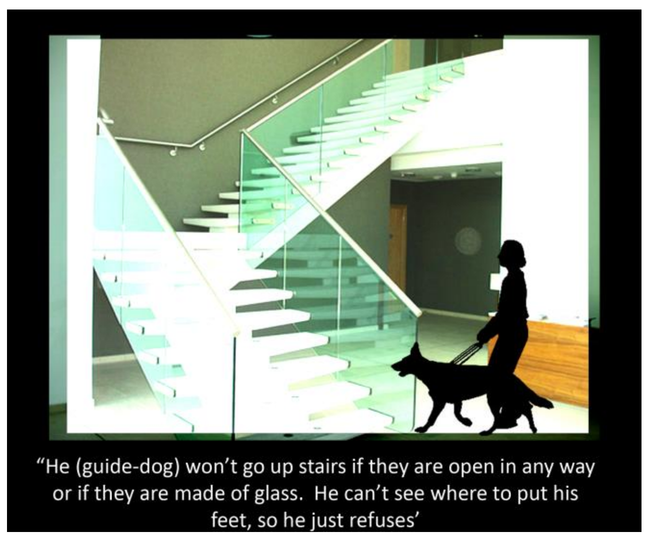

Figure 3 Memories of Hotspots in other Buildings

Another example of this type of memory-based hotspot is identified in participant's experiences of knowing what to do in the case of an emergency. James, Alfie and Jack stated they would always have to rely on someone else to help them in an emergency.

Jack explained, *'I have never been put in the real life situation of there being a fire. I don't know how good I would be at figuring it out. [...] my assistant is with me. I will be ok.'*

Evie described a situation when she was in hospital and there was a fire that caused all the doors to lock. She explained the *'mass panic'* that ensued, due to occupants being unaware the doors would lock in event of an emergency, *'we could smell the smoke and everything. [...] It was really stressful and very scary.'*

Lily identified that she was not able to read fire-exit signage because of the colors green and white. She also highlighted a need to be told what to do in the case of emergency as soon as she entered a building and explained, *'Normally in case of an emergency they say "follow the emergency signs" - but [...] I can't see them. I just say "so where would they be exactly?"'*

She continued, 'Green signs with white writing are the worst colors for me. They should tell you what to do as soon as you walk in. Like they do on a plane – the safety demonstration.'

Katie described her sense of distress and frustration of being instructed to wait in a refuge area – her fear being, *'in a large building over several floors - will I be left here?'*

She added, *'Disabled people who are mobile shouldn't have to be crowded in to refuge areas if they are capable of using stairs. I have the "D label" so I am told to go there.'*

5.2.2 Quantifiable Trace Hotspots and Observations

Within the Way-finding Trace, hotspots can be identified by occurrences such as, a clustering effect within a way-finding trace, a way-finding trace slowing in pace, a way-finding trace quickening in pace, or an interesting way-finding trace (Figure 4).

These experiences were not always described by participants during Phase 3, however they can be found in the trace and observed in the film footage. In these instances the hot spots can be understood in relation to the building elements.

Extra detail, such as situational factors (e.g. building materials or colours), temporal elements (e.g. reflective glare or temporary signage) and social interactions (e.g. input from other people) can also be understood and analyzed from the observations (figure 2).

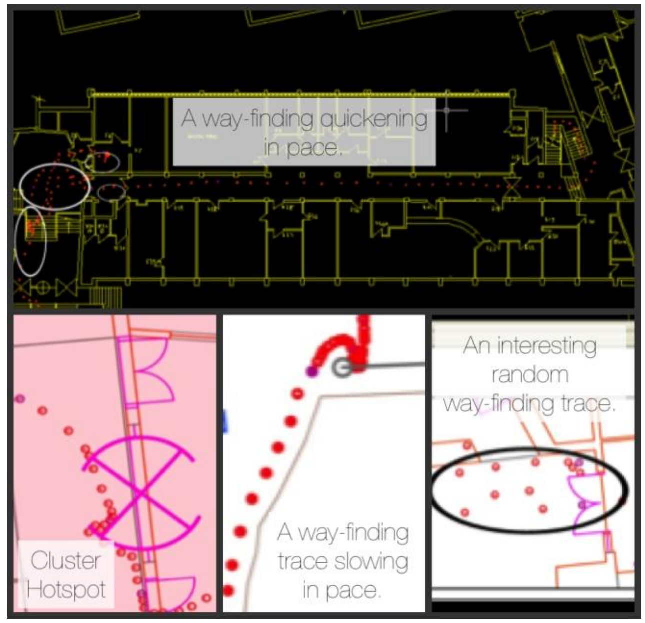

Figure 4: Finding Hotspots in the Trace

5.2.3 Experienced Hotspots not evident in the Trace

Not all hotspots were identifiable from the trace and this was evident when participants reflected on hotspots that occurred within Phase 3. For instance, Ben had a positive experience during the Way-finding Journey, which was the result of him deciding to not follow a physical path that lead to the entrance of the building. Instead, he selected his route based on a decision that it was a *'short-cut'* and explained,

'It was the shortest way to the steps. There was a path, but there were no cars so I went for it'.

However in contrast, Katie's encounter of walking through the car-park to get to the building entrance was a negative experience (Figure 5) as she struggled to find a path to the entrance. She stated,

'For a blind person, you are asking them to find their way through an open space, a nightmare, and worse still, to find their way around parked cars and moving parking cars, worse nightmare. There is a good chance of getting lost. So a different surface for a pathway through, or around the car park, should be designed in.'

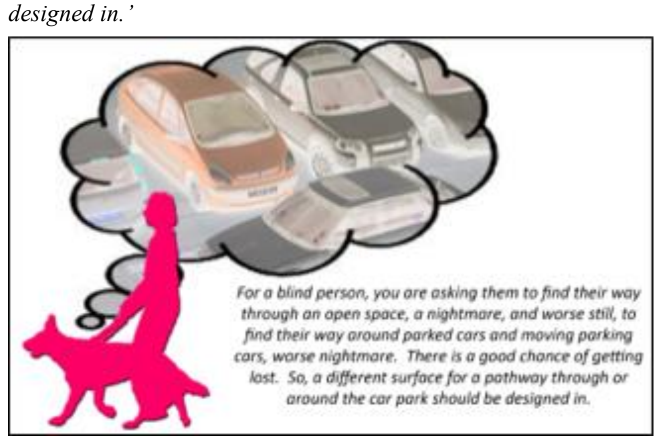

Figure 5: Experienced Hotspots not evident in the Trace.

5.2.4 Hotspots: Trace and Memories

Participant's experience of way-finding through the building in Phase 2 prompted insight into memories of hotspots experienced in other buildings. Adam, Grace, Ben and Emma all paused several times throughout their Way-finding Journeys to rest when looking through windows and over balconies. James reflected, *"I love all the different smells in a new building and I can always sniff out a good cup of coffee and cake"*. He said, *"These are the wee delights I find when I am out and about."*

5.2.5 Hotspots: Trace and Reflection

Way-finding reflection and way-finding trace (Phase 2 and 3) began to give extra insight about the hotspot experienced. Figure 6 illustrates Becky's hotspot that was encountered during the way-finding task (identifiable by the clustering and doubling up of trace) and her reflection of the experience that corridors help her to way-find. She stated,

'When you are in a corridor, and you have got definition at the sides and back it is far easier to feel safe and it is easier to concentrate and figure out "right how do I start to get from A to B to C to D?"'

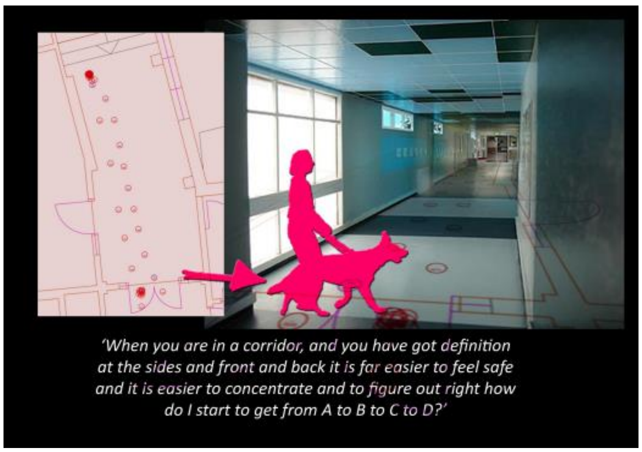

Figure 6: Trace and Reflection Hotspot

5.2.6 Hotspots: Trace, Memories and Reflection

When data-fusion occurred between all 3 Phases, this resulted in a particularly generalized finding. In James' example (Figure 7) he talked about revolving doors in Phase 1, experienced a revolving door in Phase 2 and then talked about that experience in Phase 3. He explained: *'I hate revolving doors. I have got my hand stuck in one before. I cannot see the best place to put my hand or which way to push. I can't see if someone else is coming out and if they are pushing the door. That makes me nervous. I normally try to avoid revolving doors.'*

Figure 7: Data fusion across all 3 Phases

6. DISCUSSION: BIT-KIT AND HOTSPOTS

BIT-Kit is a tool that gathers evidence to assess the impact the built environment has on people. It takes steps towards uncovering evidence as to how buildings impact on the wellbeing, mobility and independence of the people who inhabit and use them.

Although only several examples can be evidenced here, each of the hotspots can be understood in relation to the type of interaction, architectural context, spatial conditions, temporal conditions, social constraints and impact of elements of architecture (micro and macro conditions). Through uncovering the hotspots, the application of BIT-Kit was successful in uncovering evidence to assess the impact the building has on way-finders who have a range of visual impairment.

In relation to factors of accessibility in the built environment, we have exposed an obvious gap in the guidance available to architects. Buildings deemed to adhere to code and regulations are still, to varying degrees, creating exclusion for building users.

In relation to the case study, which investigated a real-world problem, BIT-Kit methods were successful in presenting novel, architectural-relevant data. The successes of BIT-Kit are that methods can be developed in direct response to an architectural case study and research problem. The multi-method approach enabled weaknesses of using one method to be mitigated. For example, understanding of way-finding trace hotspots could be gained through phases of purposeful conversations. The study also uncovered the holistic impact (positive and negative hotspots) a building has on people and the underlying reason(s) for hotspots occurring in specific locations of buildings. Used in different buildings (e.g. transport hub, cultural building or medical setting) BIT-Kit has the potential to uncover more hotspots in order to identify common problems that emerge due to lack of proper accessibility features.

Several of the findings gathered from using BIT-Kit validate specific elements of current building guidance; others differ and contest current guidance whilst some take understanding further. An important aspect of these findings is that they provide the context of the hotspot as opposed to specifying prescript 'rules'. This contrasts from current guidance as it puts the designer in the role of creating a context specific solution to the hotspot, in relation to the building.

A limitation of BIT-Kit methodology can only be applied when a building has been constructed and is inhabited by people, and not in the design stage of a new building. In future work BIT-Kit's evidence could be incorporated into digital modeling tools currently used in architecture. The combination of floor plans and context related quotes allow architecturally relevant evidence to be presented to stakeholders. Through exploring the virtual floor plans, they would be able to query points of interest to gain a deeper understanding of the accessible and inaccessible interactions. Further research is beginning to explore the need for such a tool [19].

Way-finders find it difficult to give an accurate account of their way-finding experiences [2, 11, 17]. Although BIT-Kit includes methods to dilute this limitation it needs to be acknowledged that some way-finding experiences could have been missed, or misinterpreted. In addition, the findings evidenced from the case study building may not, in their entirety, be applied to other buildings. The way-finding task limits the interactions compared to the architect's complete building floor plan. Further studies in relation to this limitation, performed in a number of different buildings in order to identify common problems that emerge due to lack of proper accessibility features is needed for more generalizable data.

The major limitation of BIT-Kit is the time and skill it takes to collect, transcribe and analyse the different types of data. If BIT-Kit, in its current form, were to be adopted in architectural practice it would prove to be costly. However, in progressing BIT-Kit further within a new project BESiDE [19] (The Built Environment for Social Inclusion through the Digital Economy) it is an objective that this limitation will be addressed and certain elements, such as analyzing the conversations and plotting the interaction trace, will become automated.

6.1 Developing BIT-Kit: What's next?

We are currently developing the methods of BIT-Kit within a new project, BESiDE [19]. BESiDE is a multi-disciplinary research project that investigates themes of ageing, wellbeing, and digital technologies within the context of built environment design. Undertaken with care home and architectural design partners, BESiDE's research analyses the holistic design insight gained from evaluating the physical environment coupled with older people's experience of their surroundings.

Through the development of a dialogue tool, indoor location sensors and sensors measuring physical activity, BIT-Kit is being utilized to gain evidence of how the built environment can facilitate physical ability and wellbeing in older people's care homes. The BESiDE project investigates how older people are currently marginalized from society via the built environment. As the project progresses it will go further by identifying where digital technologies have the potential to improve the hotspots uncovered within the context of older people' care environments.

7. CONCLUSIONS

Architecture is described as a process of "learning by doing" (Lawson, 2006). Architects work from a conceptual level 'on the drawing board', to the real-life construction of buildings. However, within architectural discourse the gathering and analysing of evidence to understand the impact of accessibility in buildings is scarce. This type of analysis is vital as building users are still experiencing disabling interactions within buildings.

The Building Interactions Toolkit (BIT-Kit) is a method that builds evidence to understand the link between buildings and the independence and mobility of the people who use them. In comparison to previous approaches, BIT-Kit allows built environment professionals to identify the location and reason behind enabling and disabling interactions within the building.

BIT-Kit has been introduced and evaluated through a case study of way-finding task in a public building by persons with visual impairment [18]. In applying a mixed-method approach of purposeful conversation, observation and building interaction data, BIT-Kit has been found to be successful in uncovering 54 'hotspots' of way-finding in a building by people with visual impairment. The evidence gathered from the way-finding scenarios, direct from the user, has illustrated novel insight into human interaction with buildings. This evidence, along with the potential of future evidence from using BIT-Kit, in different buildings experienced by different types of users, provides unique insight for architects for the future of accessible building design.

BIT-Kit is currently being developed in the BESiDE project where limitations are being addressed, collating data will be automated and new hotspots will be identified. Future research will investigate how BIT-Kit's evidence could be incorporated into the design process. A way forward is that architectural and design practitioners are empowered, through digital software 'on the drawing board', to better-understand factors of accessibility in buildings, before they are constructed. A second opportunity lies in considering the role of technology in mitigating exclusion, and enhancing accessibility, within the built environment.

8. ACKNOWLEDGMENTS

We would like to thank our research participants who gave so generously of their time for this work. This work was supported by a RCUK grant, EP/G066091/1 "RCUK Hub: Inclusion in the Digital Economy" and by RCUK grant, EP/K037293/1 "BESiDE – The Built Environment for Social Inclusion in the Digital Economy"

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